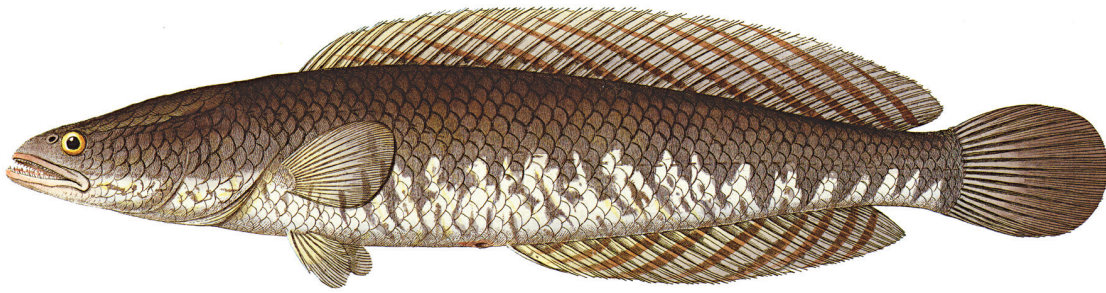
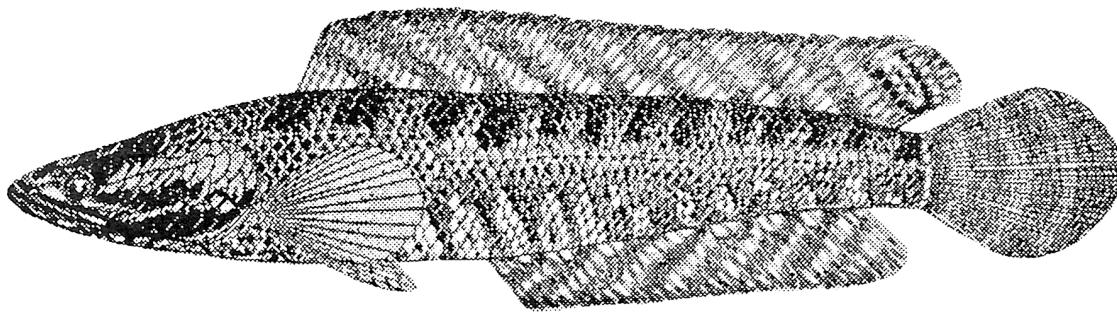


***Channa striata* (Bloch, 1793)**
Chevron Snakehead

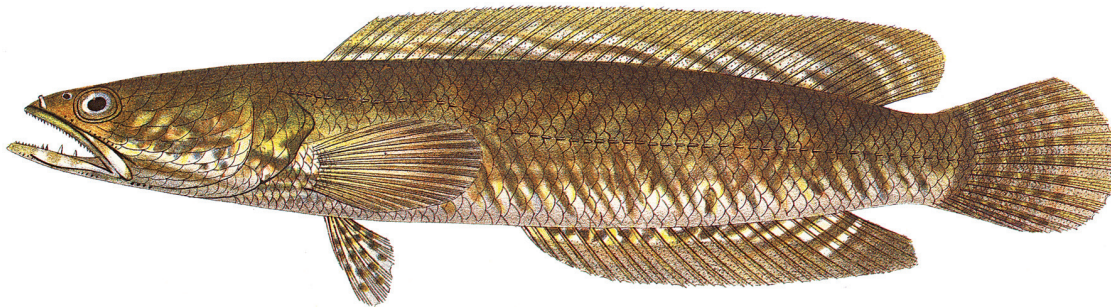


After Bloch, 1793; image reversed from original pl. 359



After Munro, 1955; juvenile

Note “pseudo-ocellus” on posterior lobe of dorsal fin, a juvenile characteristic (Lee and Ng, 1991).



After Bleeker, 1879

Original description: *Ophicephalus striatus* Bloch, 1793:141, pl. 359. Naturgeschichte der Ausländischen Fische, 7:I-xiv + 1-144, pls. 325-360. Type locality: Malabar, southwestern India. Syntypes: ZMB 1400; ZMB 6522.

Synonyms: *Ophiocephalus wrahl* Lacepède, 1801:552.

Ophiocephalus wrahl Hamilton, 1822:60, 367, pl. 31.

Ophiocephalus chena Hamilton, 1822:62, 367.

Ophicephalus planiceps Cuvier, 1831:424.

Ophicephalus sowarah Bleeker, 1845.

Ophiocephalus vagus Peters, 1868:260.

Ophiocephalus philippinus Peters, 1868:262.

(?)*Ophiocephalus melanopterus* Smith and Seale, 1906.

Common names: **chevron snakehead**; striped snakehead; banded snakehead; common snakehead; soali (Pakistan); murrel (India); haal, shawl, shol (Assam, India); shol (West Bengal, India); morrul, morl, soura (Bihar, India); sowl, dhoali, carrodh (Punjab, India); dolla (Jammu, India); sola (Orissa, India); korramennu, korra-matta (Andhra Pradesh, India); sowrah, veralu, kaunan (Kerala, India); pooli-kuchi, koochinamarl (Karnataka, India); sohr, dekhu (Mararashtra, India); hal path maha, lulla (Sinhalese, Sri Lanka); viral (Tamil, Sri Lanka); pla chon or pla chorn (Thailand); trey phtuok (juveniles) and trey raws (adults; Cambodia); ikan aruan, haruan, ruan, tomam paya (Malaysia); gabus (Java); delak, gabus, telak (Kalimantan), cá lóc (Vietnam); dalag, dalak (Tagalog or Moro, Philippines); bakule or bulig (young; Tagalog or Moro, Philippines); pongee (Hawaii, although that name is a general name for snakeheads; Mike Yamamoto, personal commun., 2003).

Native range: Pakistan (Indus River basin; Mirza, 1975), most drainages of India, southern Nepal (Koshi, Gandaki, and Karnali River basins; Shrestha, 1990), Sri Lanka (Mendis and Fernando, 1962; Fernando and Indrassna, 1969; Pethyagoda, 1991); Bangladesh, Myanmar, Thailand, Cambodia, southern China, Malay Archipelago including Malaysia, Sumatra, Borneo (Pethyagoda, 1991; Rainboth, 1996; Jayaram, 1999); Sabah (Inger and Kong, 1962); western Java (Giltay, 1933; Roberts, 1993); Vietnam, Laos (Yên and others, 1992; Kottelat, 2001a,b). This is an amazingly extensive "native" distribution for any freshwater fish, indicating that *Channa striata* is quite probably a species complex.

Introduced range: *Channa striata* has been considered the most widely introduced species of snakehead. Various reports indicate it was released into Hawaii before 1900, established (Jordan and Evermann, 1903; Cobb, 1905; Smith, 1907; Tinker, 1944; Brock, 1952, 1960); Madagascar, in 1978, established (Raminosoa, 1987; Reinthal and Stiassny, 1991; Stiassny and Raminosoa, 1994; Lévêque, 1998); Philippines, date unknown (Seale, 1908; Herre, 1924, 1934; Conlu, 1986); Vogelkop Peninsula, Papua, Indonesia, probably during 1970s or 1980s, established (Allen, 1991) and identification confirmed by photographs provided by Gerald Allen (personal commun., 2002); Sundaland, Sulawesi, Lesser Sundas, Moluccas, date unknown, established (Welcomme, 1981; Kottelat and others, 1993; Lever, 1996); Fiji, establishment questionable (Maciolek, 1984; Eldredge, 1994); Mauritius, established (Parameswaran and Goorah, 1981; Welcomme, 1988; Lever, 1996); New Caledonia, establishment questionable (Maciolek, 1984); Guam, introduction unsuccessful (Maciolek, 1984; Eldredge, 1994). Herre (1924) recorded the source of introduction into Hawaii as southern China. Kottelat and others (1993) reported some populations in China to have been introduced but gave no specific locations.

Its introduction into the Philippines probably occurred in the early to mid-1800s, indicated by two synonyms (*Ophiocephalus vagus* and *O. philippinus*) described from the Philippines by Peters (1868). Although Jayaram (1999) included Borneo in the native range of this species, Roberts (1989) hinted that its presence in western Borneo may have resulted from introductions.

Ralf Britz (personal commun., 2002) has advised that reports of this species from Madagascar are in error, the result of misidentification of the blotched snakehead, *Channa maculata*. He also examined a specimen labeled as *C. striata* (USNM 126588), collected by Jordan and Evermann on Oahu, Hawaii, in 1901, that was also *C. maculata*. Two specimens we borrowed from the Bernice P. Bishop Museum in Honolulu (BPBM 1759 and BPBM 3798), collected in the early 1900s on Oahu and labeled as *C. striata*, are *C. maculata*. Specimens borrowed from the California Academy of Sciences (CAS 17710, 1 specimen; CAS 108133, 3 specimens) collected on Oahu also proved to be *C. maculata* and not *C. striata*. We are convinced that all early records of *C. striata* from Hawaii are misidentifications of *C. maculata*. Although most records for Hawaii cite establishment only on Oahu, Morita (1981) reported that it also occurred on Kauai. *Channa striata* is now present and established on Oahu but confined to a fish culture facility. The first imports of this species occurred in the early 1990s. It is likely that many identifications of *C. striata* on islands of the Indian and Pacific Oceans are in error and that *C. maculata* may prove to be more widely introduced than previously thought.

Following publicity accompanying discovery of an established population in Maryland of northern snakehead, *Channa argus*, in June-July 2002, the lead investigator received an email message from an individual (Clifford Faik) in East Sepik Province, Papua New Guinea, who had seen the northern snakehead report on the CNN website. He stated that a similar snakehead was now present in rivers of Sepik Province.

Temperature regimes at that locality would preclude presence of northern snakehead, but is likely indicative that the chevron snakehead is the species involved, probably introduced from populations established in Papua, Indonesia. If so, this would be the first record of a snakehead from Papua New Guinea.

Size: To 90 cm (Bardach and others, 1972); 91.4 cm (Sen, 1985). Can attain a length of 30-36 cm in 1 year (Bhatt, 1970). Talwar and Jhingran (1992) stated that this species is sexually mature at 30 cm, but added that 2 years were required to reach that size. Murugesan (1978), however, recorded a growth rate of 1.3 to 3.0 mm/day for the first 3 months, slowing to 0.3 to 0.9 mm/day thereafter. He also reported lengths of 25-27 cm in 13½ months and 23.4-31.7 cm in 9½ months in Kerala State, India; 32 cm in 2 years in West Bengal; and 30.51 cm in 2 years in Madras. In rivers of Uttar Pradesh, chevron snakeheads grew to 32 cm in 2 years.

Habitat preference: Freshwater ponds and streams, usually in stagnant muddy waters; primarily found on plains in India (Talwar and Jhingran, 1992). It occurs in reservoirs in Sri Lanka (Fernando and Indrassna, 1969). Nevertheless, in Malaysia this species is reported to exist in rivers, lakes, swamps, rice paddies, mining pools, and roadside ditches (Mohsin and Ambak, 1983; Lee and Ng, 1991). Ng and Lim (1990) listed this species from “open country areas,” adding that it is the primary snakehead in shallow waters (1 m or less) with dense vegetation. In India, it can be found in reservoirs and rice paddies (Jhingran, 1984). In Keoladeo National Park, Bharatpur, Rajasthan, north-central India, it may be found in open water to dense mats of aquatic vegetation (Kumar and Mittal, 1993). Herre (1924), Umali (1950), and Conlu, 1986) recorded it from lakes and lowland rivers in the Philippines, and its introduction to two crater lakes at an altitude about 1,050 m above sea level. Kottelat (1998) reported a preference for “standing waters.” Lee and Ng (1991) noted that this species seems to be the most adaptable snakehead, tolerating “quite foul water” and able to move overland.

Channa striata is an obligate airbreather. Vivekanandan (1977a,b) stated that the breathing organ is developed in about 60 days during growth from a length of 1 to 4.5 cm at 26-28 °C. Singh and others (1986) noted that at 28 °C, this species breathes aquatically until 18 to 20 days following hatching when young reach a length of 1.1-1.2 cm and, thereafter, becomes a bimodal breather. They measured a decrease in oxygen uptake

through the gills and skin of almost 42 percent once bimodal respiration began. Pandian (1982) reported that fingerlings of this species spend up to 15 percent of the time in surfacing and related activities.

Varma (1979) recorded a pH range for *Channa striata* of 4.25 to 9.40 with 100 percent survival over 72 hours, and 90 percent survival at pH 3.10 for the same period.

Temperature range: No specific information, but native range lies between about 32° N and 7° N, indicative of a fish that is temperate to tropical.

Reproductive habits: Lee and Ng (1991) indicated the species as solitary except during spawning seasons. In India, pairs breed during most months of the year, laying a few hundred to more than 1,000 amber-colored eggs (Parameswaran and Murugesan, 1976a; Talwar and Jhingran, 1992). Peak spawning coincides with peak rainfall (Parameswaran and Murugesan, 1976a). Howell (1913) said the eggs average about 1.25 mm and are nonadhesive, hatching in 1 to 3 days. Females mature about 30 cm in length at about 2 years of age (Talwar and Jhingran, 1992; Ali, 1999). Parents clear a shallow depression by biting off aquatic vegetation (Ling, 1977). Nevertheless, Alikunhi (1953) remarked that *Channa striata* will spawn in the absence of vegetation. Eggs float to the surface after fertilization (Lee and Ng, 1991). The pelagic eggs are guarded by both parents in the Philippines (Lowe-McConnell, 1987) and possibly throughout the native range of the species. Nevertheless, Herre (1924) stated that one or the other parent guards the nest at all times, and that if food becomes scarce, parents become cannibalistic on the young. He further indicated that in the Philippines, *C. striata* spawns throughout the year and that many, perhaps all, breed twice annually. Ali (1999) confirmed ripe females present throughout the year in ricefields in Perak, northwestern Malaysia. Peak spawning in southwestern Sri Lanka occurs between May and September, with a secondary spawning October through December (Kilambi, 1986). Jhingran (1984) cited fecundity as 3,000-30,000 ova. Lee and Ng (1991) stated that they had collected fry without seeing parents nearby. They also said that eggs hatch in 3 days in Malaysia, the fry developing a deep orange color. This pattern persists until the young reach a length of 15 mm when only an orange lateral stripe remains. At 40 mm in length, all orange color is lost but a “pseudo-ocellus” appears on the posterior lobe of the dorsal fin, a characteristic lost in adulthood. Mookerjee and others (1948) described and illustrated early development of *C. striata*.

Feeding habits: Carnivorous, feeding on worms, prawns, frogs, and especially other fishes (Mohsin and Ambak, 1983). Reported as a solitary (except during breeding season), territorial, ambush feeder (Lee and Ng, 1991). Conlu (1986) stated that young fry feed on algae and protozoans, juveniles feed on small crustaceans, and “adults are highly carnivorous, dreaded predators of other pond fish.” She added that this fish is used as a predator to control tilapias in culture ponds. Jhingran (1984) cited larvae as feeding “on insects, water fleas, and fish fry,” juveniles preferring “dipteran larvae, zooplankton, and fish fry,” and adults as “piscivorous.” Mahan and others (1978) reported that *Channa striata* (32 individuals ranging from 3.5 to 36.7 cm in length) fed almost exclusively on shrimp (47 percent by volume) in a lake in central Java. Dasgupta (2000) found that this snakehead consumed primarily insects (40 percent) followed by fishes (30 percent) and crustaceans (10 percent) in waters of West Bengal, India. Rao and others (1998) noted a preference for crustaceans and fishes from ponds and canals of East Godavari District, Andhra Pradesh, southeastern India. Ng and Lim (1990) described the enlarged canine teeth of *C. striata* as “cylindrical in cross section ... ideal for gripping, killing, and tearing.”

Characters: Gular region of head without patch of scales. Mouth large; lower jaw with 4-7 canines behind a single row of villiform teeth that widen to 6 rows at the jaw symphysis; villiform teeth on prevomer and palatines. Pectoral fin about half of head length. Dorsal fin with 37-46 rays; anal fin rays 23-29; pectoral rays 15-17; pelvic rays 6; caudal fin rounded. Scales on top of head large with a rosette of head scales between orbits, with frontal head scales forming central plate of rosette; 9 scale rows between preopercular angle and posterior border of orbit; predorsal scales 18-20; scales 50-57 in lateral series (Talwar and Jhingran, 1992). Coloration is quite variable in this species or species complex. The dorsum is often dark brown to black, typically obscuring the chevron-like markings dorsally. A distinguishing marking, however, is the dark stripe extending from just above the maxillary posteroventrally toward the opercular curvature.

Commercial importance in the United States: Introduced population is utilized as a food resource in Hawaii (Maciolek, 1984), although the species involved was not *Channa striata* but *C. maculata*, the result of century-old misidentifications. In addition to live fish, several thousand metric tons of frozen snake-

heads are reported as being imported annually for food purposes into mainland United States. It is unknown how much of that market involves *C. striata*.

During fiscal year 1999, the U.S. Department of Agriculture Small Business Innovation Research Program funded a Phase II project to the Hawaii Fish Company of Waialua, Hawaii, \$230,000 for 24 months, to develop commercial culture of *C. striata*. Phase I research had established feasibility of rearing striped snakeheads in captivity, spawning, and studies on rearing juveniles on artificial diets. Phase II was targeted to production of larvae and juveniles through induced spawning, additional studies on feeding, and cost-effective grow-out performance to marketable size. Phase III was designed to result in a commercial effort to produce farm-raised snakeheads for Hawaii, mainland U.S., and Canada, and was to be funded (\$300,000) by the Wah Wah Seafood Company, Inc., of Honolulu. Phase III, however, was never funded.

In retrospect, importation of *Channa striata* to Hawaii is quite recent. Perhaps based on the belief that this species had been established in Hawaii for nearly a century, a permit was issued in the early 1990s to Arlo Fast of the University of Hawaii to import *C. striata* for culture research on Coconut Island in Kaneohe Bay. A second permit to import *C. striata* was issued to Dr. Fast in 1995 in cooperation with the person who currently cultures the species in a rockpit area at Mokuleia. The culturist had the only permit from the Hawaii Department of Agriculture to import *C. striata* with restrictions that sale to consumers must be of fresh-killed or cooked fish (Domingo Cravalho, Jr., personal commun., 2002).

This species often appears in aquarist-oriented websites and has been sometimes listed for sale by commercial aquarium websites. Interest in its use as an aquarium fish seems to be limited due to the size it attains and its aggressive nature toward other fishes.

On July 24, 2002, a specimen of *Channa striata* was purchased from a market in San Diego, California, where at least two other individuals of the same species were observed (Richard Rosenblatt and Phil Hastings, personal commun., 2002). All three were dead, on ice. The appearance of the specimen sent to us in a digital photograph seems to be of a freshly dead individual, with no cloudiness visible in the eye.

Commercial importance in native range: *Channa striata* is reported as being cultivated in Pakistan and India. There is a “tank fishery” for this species in Tamil Nadu, India. Tanks in India and Sri Lanka are

“ancient irrigation reservoirs” (Fernando and Indrassna, 1969). They stated that there were more than 1,000 tanks in Sri Lanka alone. In India, the chevron snakehead is described as a popular and highly prized fish, widely distributed, and the most economically important species of the genus (Talwar and Jhingran, 1992). *Channa striata* is one of three species of snakeheads commercially fished in Lake Jaisamand, the oldest reservoir in India (Rao and Durve, 1989). Fernando and Indrassna (1969) stated that it is the only species of snakehead in Sri Lanka of economic value, although three additional species (*C. gachua*, *C. marulius*, and *C. punctata*) are used as food fishes. It is also cultured in Vietnam (Pantulu, 1976; Bard, 1991), Thailand, Java (Hofstede and others, 1953), and the Philippines (Guerero, 2000). Bard (1991) noted that this species is the most expensive fish produced by aquaculture in northern Vietnam. Ali (1999) cited it as “a popular food fish in Malaysia” remarking that ricefields have provided the largest source of this fish. Populations in Malaysia are reported to be depressed due, apparently, to overfishing, raising costs for live specimens. China is culturing *C. striata* and some of the product is being canned for sale in Malaysia (Wan Ahmad, personal commun., 2001).

Lee and Ng (1991) cited this species as the most economically important member of the snakeheads and noted that it is cultured throughout most of its range. Hofstede and others (1953) cited this species as bringing “the highest prices at the markets” in Indonesia. It is sold either fresh or alive in Cambodian markets (Rainboth, 1996). In the Danau Sentarum Wildlife Reserve of Kalimantan, chevron snakehead comprised 13 percent of the setline fish catch using small (size 12-16) hooks from the Kapuas River (Dudley, 2000).

Ng and Lim (1990) and Lee and Ng (1991) indicated that *Channa striata*, along with *C. micropeltes* and *C. lucius*, are utilized for medicinal purposes, particularly in Indonesia and Malaysia. Mention was made of use in a postnatal diet and during recuperation from illnesses or surgery (Lee and Ng, 1991). While no specifics were given as to how the fish were used following surgery, a neighbor of one of the authors (WRC), a Malaysian by birth, said that the oils from the “haruan” are used to greatly reduce scarring. She added that she had seen the results and “it is true” that scar tissue is dramatically reduced to a minimum.

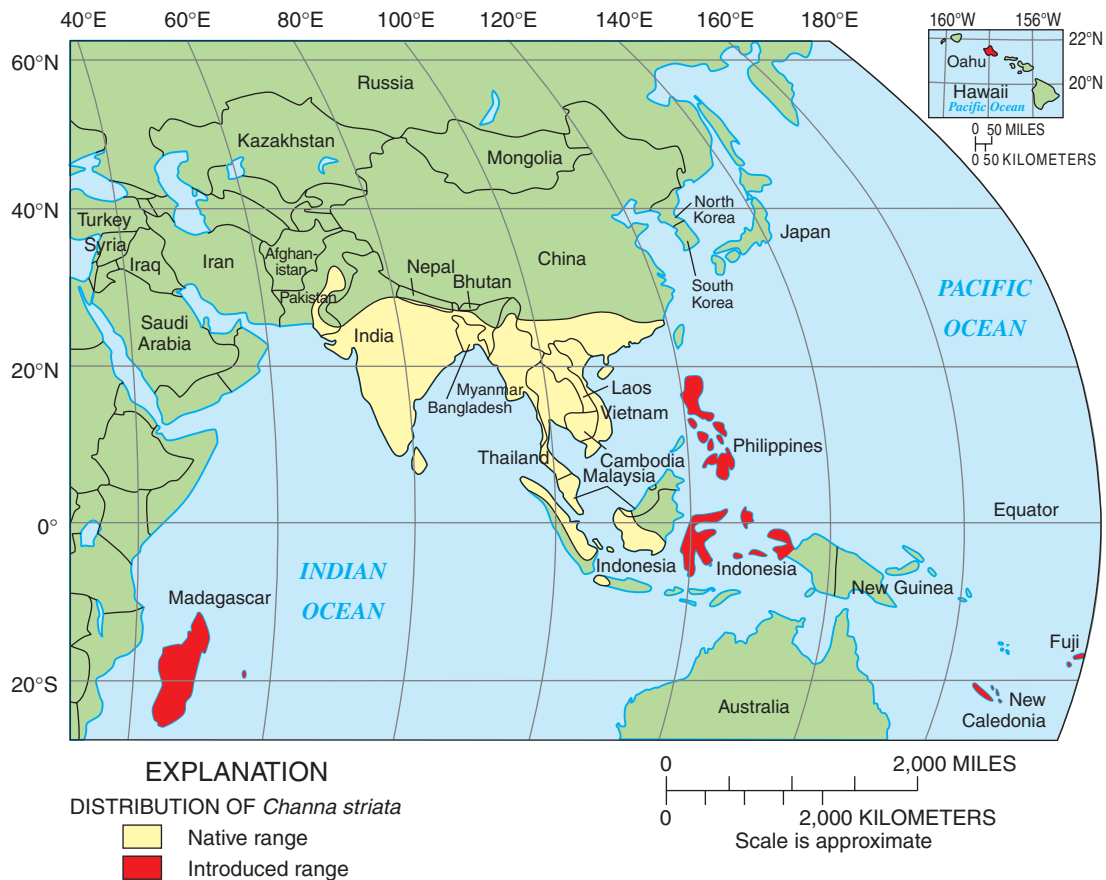
Cream extracts of haruan tissues contain high levels of arachidonic acid, a precursor of prostaglandin, essential amino acids (particularly glycine), and polyunsaturated fatty acids necessary to promote prostaglandin synthesis. Treating wounds with these extracts has been demonstrated to promote synthesis of collagen fibers better than standard use of Cetrimide, an antimicrobial quaternary ammonium compound, thus increasing tensile strength (Baie and Sheikh, 2000).

Lee and Ng (1991) indicated that the flesh of these larger snakeheads is rejuvenating following illnesses, prepared by being double-boiled with herbs, and only the soup is consumed. Nevertheless, for the soup to be effective in recovery, it is firmly believed that the fish must be killed just before cooking, dispatched with careful but firm blows to the head with a mallet. Herre (1924) reported much the same for the Philippines. Conceivably, this could be a reason that obtaining live snakeheads in live-food fish markets is considered important to some persons of southeast Asian descent living in the United States. Seale (1908) cited this species “as one of the most wholesome fishes and are given to invalids” in India.

Bard (1991) noted that *Channa striata* is cultured in Vietnam and is a highly desired and expensive fish in the markets of Hanoi, with a price/kg matching that of beef.

Environmental concerns: Adults of this species are considered to be highly predacious, ambush feeders on other fishes. In addition, their adaptability to living in turbid or clear waters, their apparent ability to tolerate subtropical to warm temperate climates, suggests the probability of establishment if introduced into waters of the extreme southern U.S. The apparent northern limit within its native range (32° N) is equivalent to a potential range from Savannah, Georgia, to just north of Ensenada, Baja California del Norte, México, in North America. Temperature regimes in the southwestern U.S. would permit establishment well north of 32° N, probably as far north as the Los Angeles basin, California; Phoenix, Arizona; or Las Cruces, New Mexico.

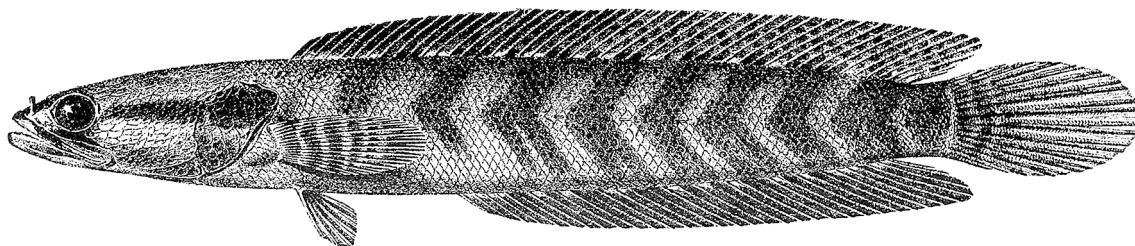
Comments: Banerjee and others (1988) recorded the diploid chromosome number of *Channa striata* from India as 40, but Donsakul and Magtoon (1991) reported a count of 44 for this species from Thailand, indicating that it represents a species complex.



Distribution of *Channa striata*

See comments above under **Introduced range**, as some reports of *C. striata* on Indian Ocean (for example, Madagascar) and Pacific Islands (for example, Hawaii) are misidentifications of *C. maculata* that require further investigation.

***Parachanna africana* (Steindachner, 1879)**
Niger Snakehead



After Boulenger, 1916

Original description: *Ophiocephalus africanus* Steindachner 1879:31. Über einige neue und seltene Fischarten aus den zoologischen Museen zu Wien, Stuttgart und Warschau. Anz. Akad. Wiss. Wien. 16(4):29-34. Type locality: Lagos, Nigeria. Holotype: SMNS (no number provided).

Synonyms: *Channa africanus* (Steindachner, 1879).

Parophiocephalus africanus (Steindachner, 1879).

Common names: **Niger snakehead**; African snakehead.

Native range: Southern Bénin to southern Nigeria, primarily the Ouémé River and Niger basin (Bonou and Teugels, 1985; Skelton, 1988).

Introduced range: Introductions unknown.

Size: To 32 cm.

Habitat preference: Bonou and Teugels (1985) noted that there was little known of the biology of this snakehead. Daget and Iltis (1965) considered this species as a Guinean form that occupied waters in forested areas. Teugels and others (1992) commented that this species is limited to coastal sections of rivers.

Temperature range: No specific information. Nevertheless, the native range is equatorial, indicating a strictly tropical species.

Reproductive habits: No specific information located. Likely a nest builder that provides parental protection to young like other snakeheads.

Feeding habits: No specific information. In considering this species as a game fish, Copley (1952) remarked that it ate frogs and worms, as well as fishes. Probably a thrust predator like other channid fishes.

Characters: Patch of scales present in gular region. No canines on prevomer or palatines. Transverse scales 19-24; lateral line scales 73-83. Dorsal rays 45-48; anal rays 32-35. Head slightly depressed anteriorly and covered with large scales. Lower jaw slightly longer than upper jaw with 3 to 4 large canine teeth. Coloration distinct among African snakeheads in having a series of forward-pointing chevrons on the side of the body posterior to the pectoral fins that extend upward to the base of the dorsal fin (Bonou and Teugels, 1985).

Commercial importance in the United States: Sometimes listed on aquarist-oriented websites and has been periodically sold through aquarium fish retailers. Unknown in live-food fish markets.

Commercial importance in native range: Unknown, but probably available in live-food fish markets.

Environmental concerns: Likely a thrust predator. Native range is equatorial indicating that if introduced this species would be restricted to tropical/subtropical waters.



Parachanna africana